

1.2 A Small Independent Producer's Design, Construction and Operation of a Flue Gas Injection Project, East Edna Field, Okmulgee County, Oklahoma

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Abstract

Driver Production was one of four companies awarded a grant from the U.S. Department of Energy as a result of a competitive procurement for small independent producers to demonstrate economic application of gas repressurization of oil reservoirs. Driver Production proposed a Flue Gas Injection (N_2 and CO_2) project in a five-spot pattern in the East Edna Field, Okmulgee County, Oklahoma, USA. The paper describes the design, construction, start-up, expansion and operation of a flue gas project that uses produced natural gas as the energy source for combustion and compression. Changing the engine to a larger unit to allow for higher gas injection capacity and for injection at higher pressure demonstrated the need for critical control of flue gas quality to minimize corrosion problems associated with CO_2 injection. The project has demonstrated that even small operators can successfully implement gas repressurization to increase oil production from a pressure-depleted reservoir. The project, initiated in 1996, continues to increase oil and natural gas production as long as flue gas is injected. The economics of the project and success to date have prompted the project operator and other operators who have visited and analyzed the project to consider application of flue gas in their small pressure depleted reservoirs.

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**A SMALL INDEPENDENT PRODUCER'S DESIGN, CONSTRUCTION AND
OPERATION OF A FLUE GAS INJECTION PROJECT,
EAST EDNA FIELD, OKMULGEE COUNTY OKLAHOMA, USA**

Based in part on SPE 39637
PRESENTED AT 1998 SPE / DOE
IMPROVED OIL RECOVERY CONFERENCE,
TULSA, OKLAHOMA
and

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CONSTRUCTION AND OPERATION OF A FLUE GAS
INJECTION PROJECT, EAST EDNA FIELD,
OKMULGEE COUNTY OKLAHOMA, USA**

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OUTLINE OF PRESENTATION

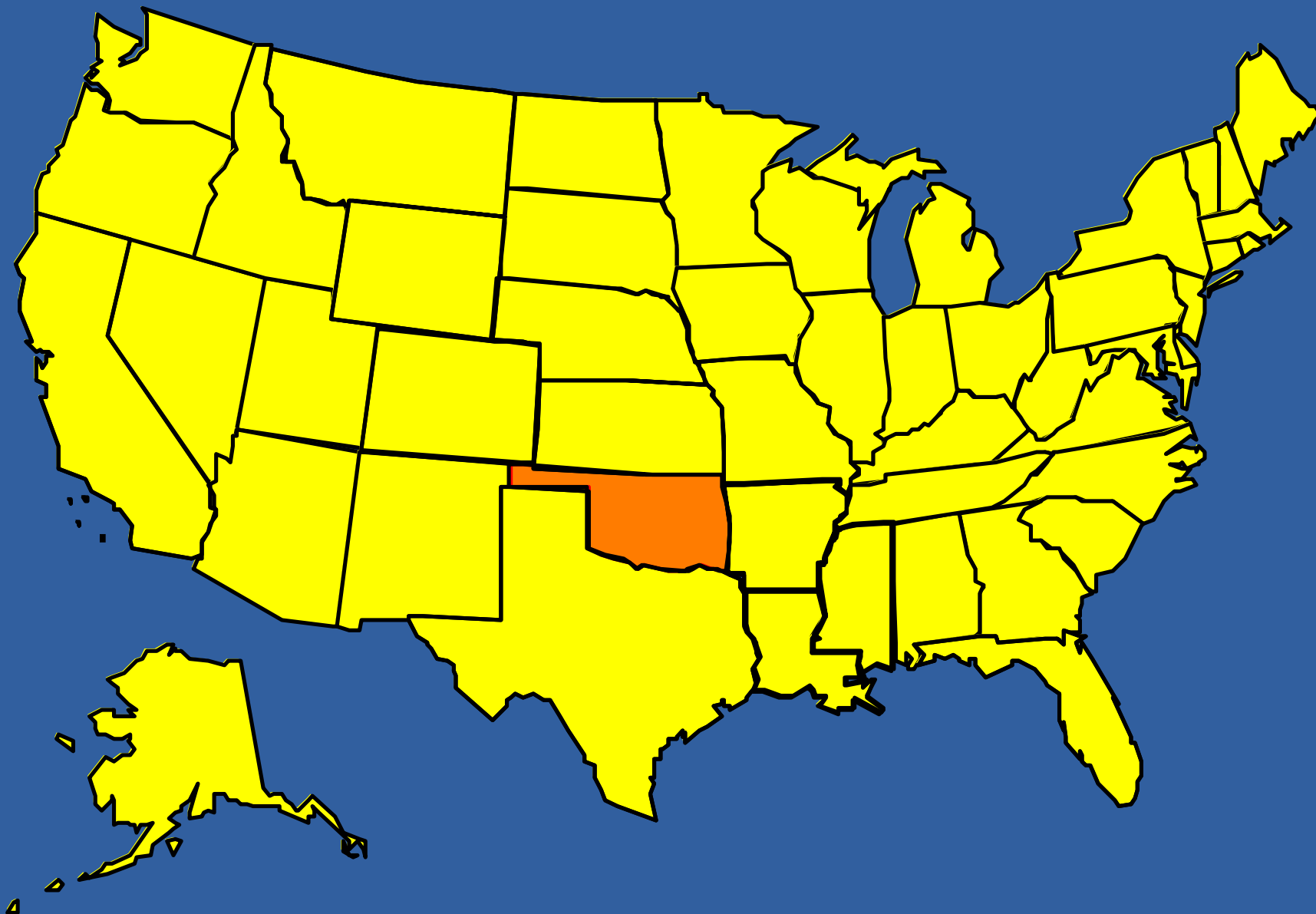
- * COMPANY BACKGROUND AND PROJECT OBJECTIVE
- * FIELD HISTORY
- * CONDITIONS AT START OF PROJECT
- * DESIGN, CONSTRUCTION AND STARTUP OF SYSTEM
- * RESPONSE TO GAS INJECTION
- * ECONOMICS OF PROJECT
- * LESSONS LEARNED FROM PROJECT
- * 20/20 HINDSIGHT and TWO YEARS OF LOW OIL PRICES 1997-1998
- * FUTURE GAS REPRESSURIZATION BY DRIVER PRODUCTION

BACKGROUND AND OBJECTIVE OF PROJECT

DRIVER PRODUCTION COMPANY IS A SMALL FAMILY-OWNED, TWO PERSON COMPANY, 100% EQUITY IN ALL PROJECTS, NEVER HAS SOLD A PROPERTY

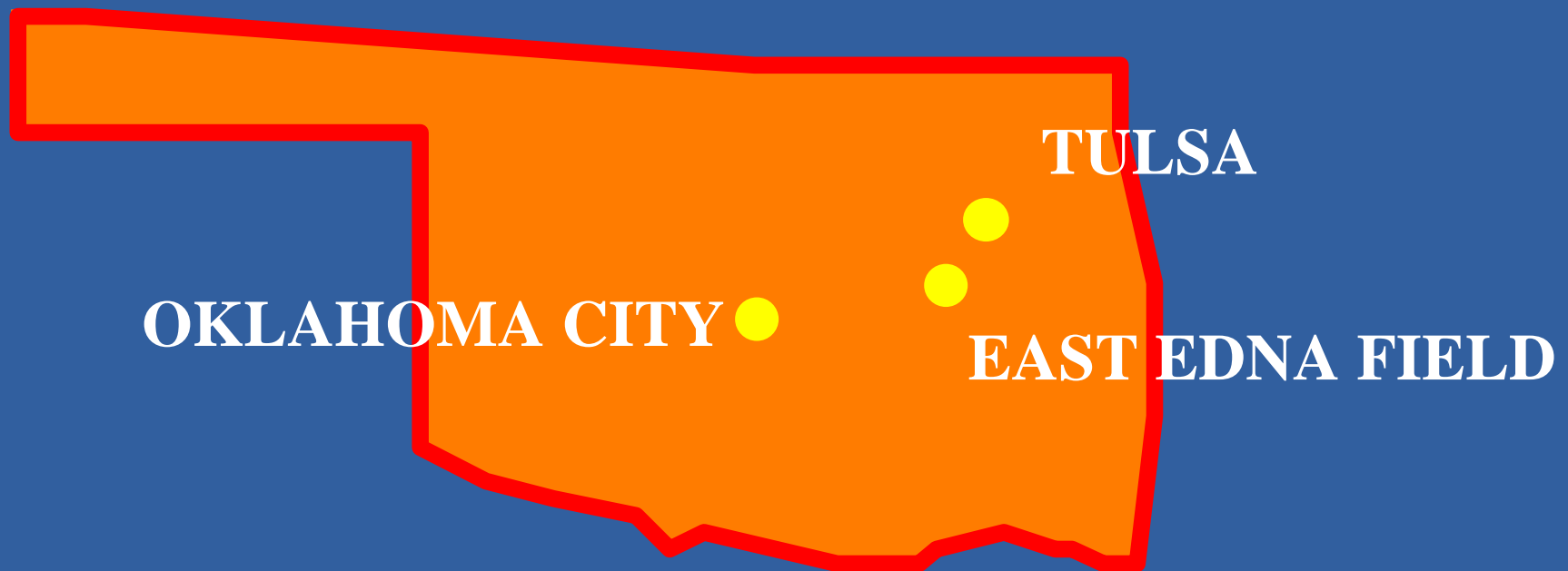
DRIVER RESPONDED TO A 1995 USDOE COMPETITIVE SOLICITATION FOR PROPOSALS FOR COST-SHARED FIELD PROJECT (one year time limit) FOR APPLICATION OF GAS REPRESSURIZATION BY SMALL INDEPENDENT OPERATORS

AWARDED Project - Spring 1996 for Flue Gas Repressurization Project for purpose of increasing oil production from marginal stripper well lease operated by small independent



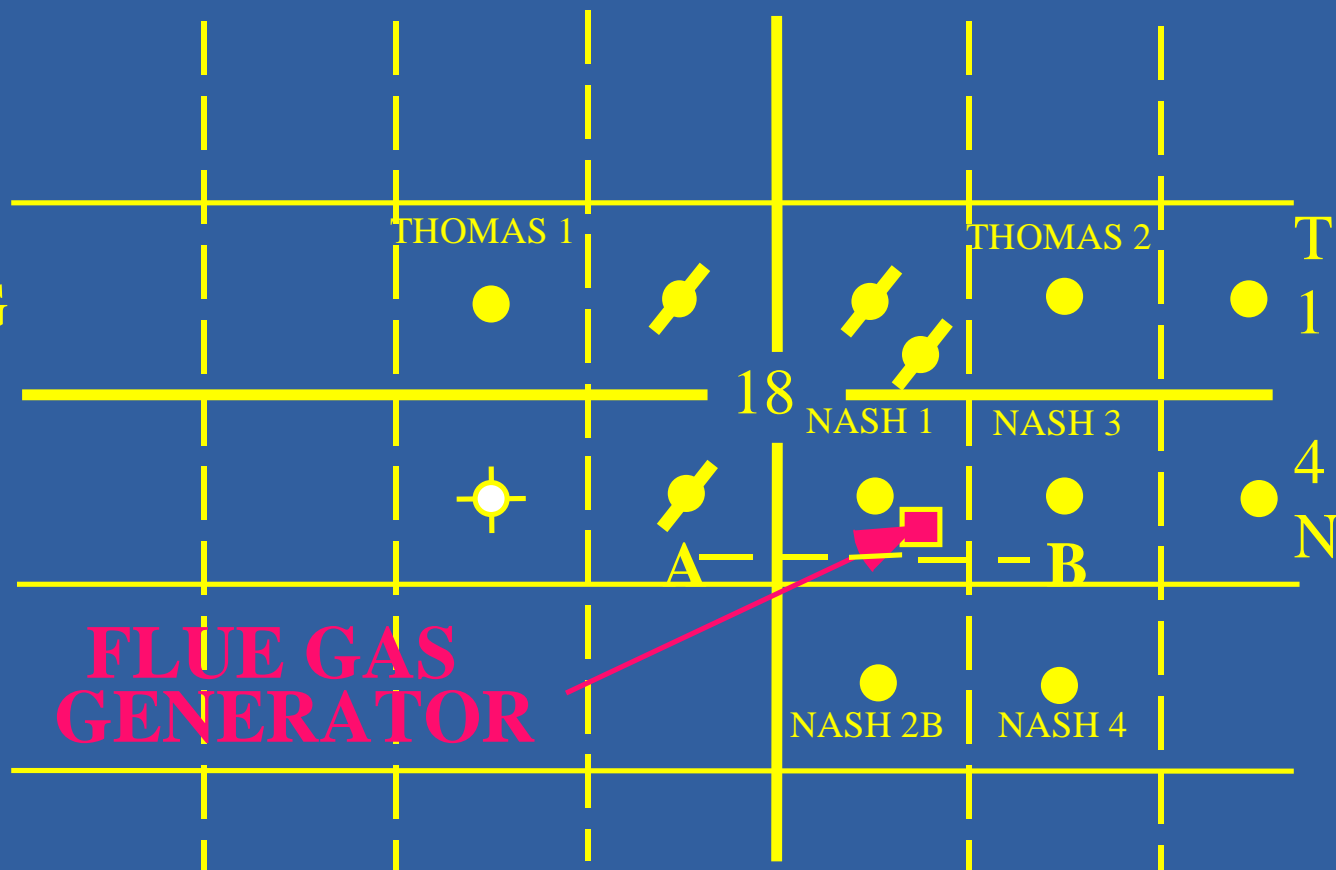
EAST EDNA FIELD, OKMULGEE OKLAHOMA

40 MILES SOUTHWEST OF TULSA



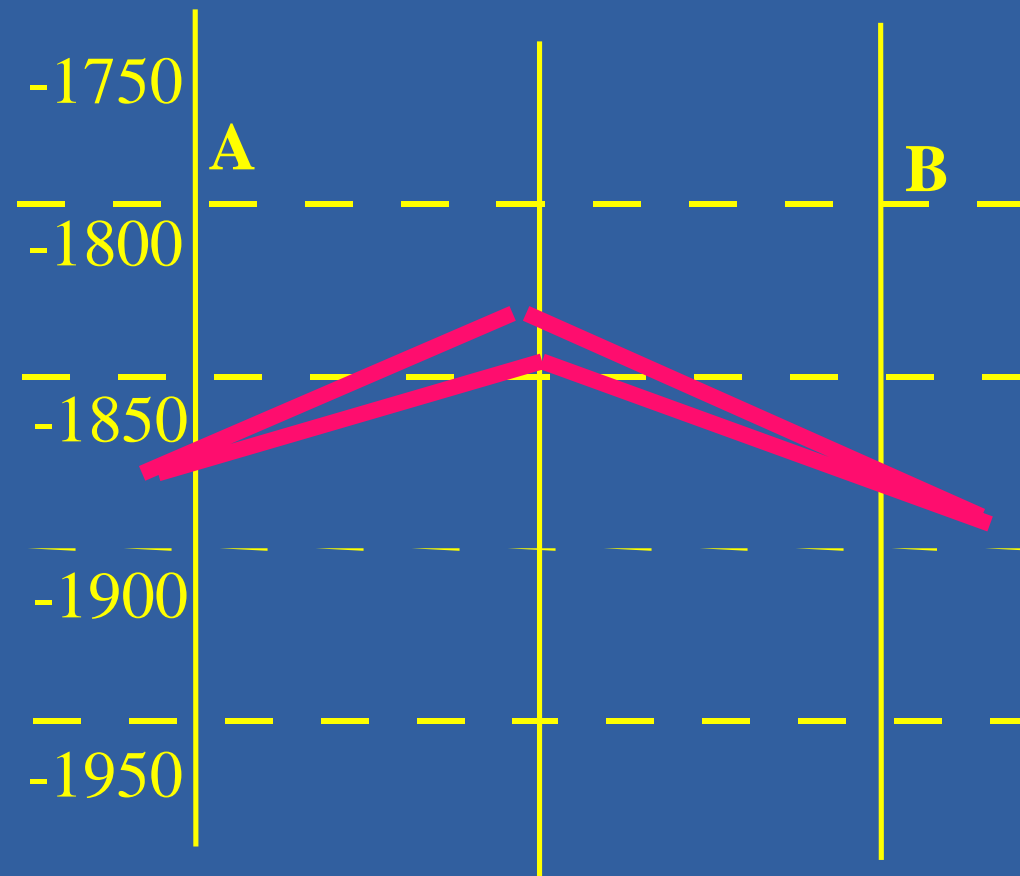
EAST EDNA FIELD LAYOUT

10
ACRE
SPACING



R 11 E

CROSS SECTION OF LINE A TO B IN DUTCHER SANDSTONE

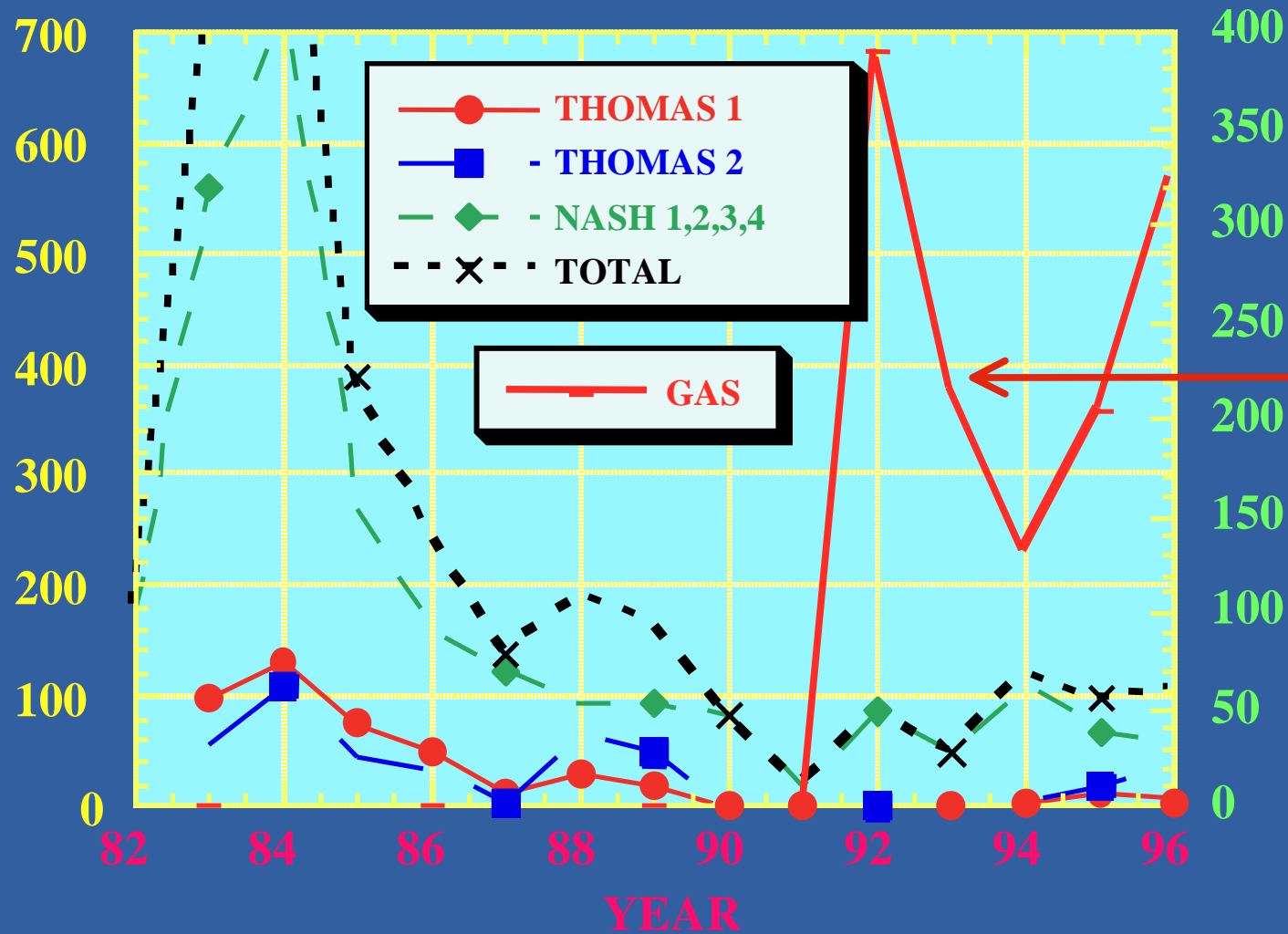


CONDITIONS AT START OF PROJECT

AVERAGE PRE-INJECTION DAILY PRODUCTION

Well	Oil B/D	Gas MCF/D	Water B/D
Thomas 1	0.5	—	Trace
Thomas 2	0.3	—	Trace
Nash 1,2,3,4	<u>1.75</u>	<u>11.6</u>	<u>Trace</u>
TOTAL 6 WELLS	2.55	11.6	Trace

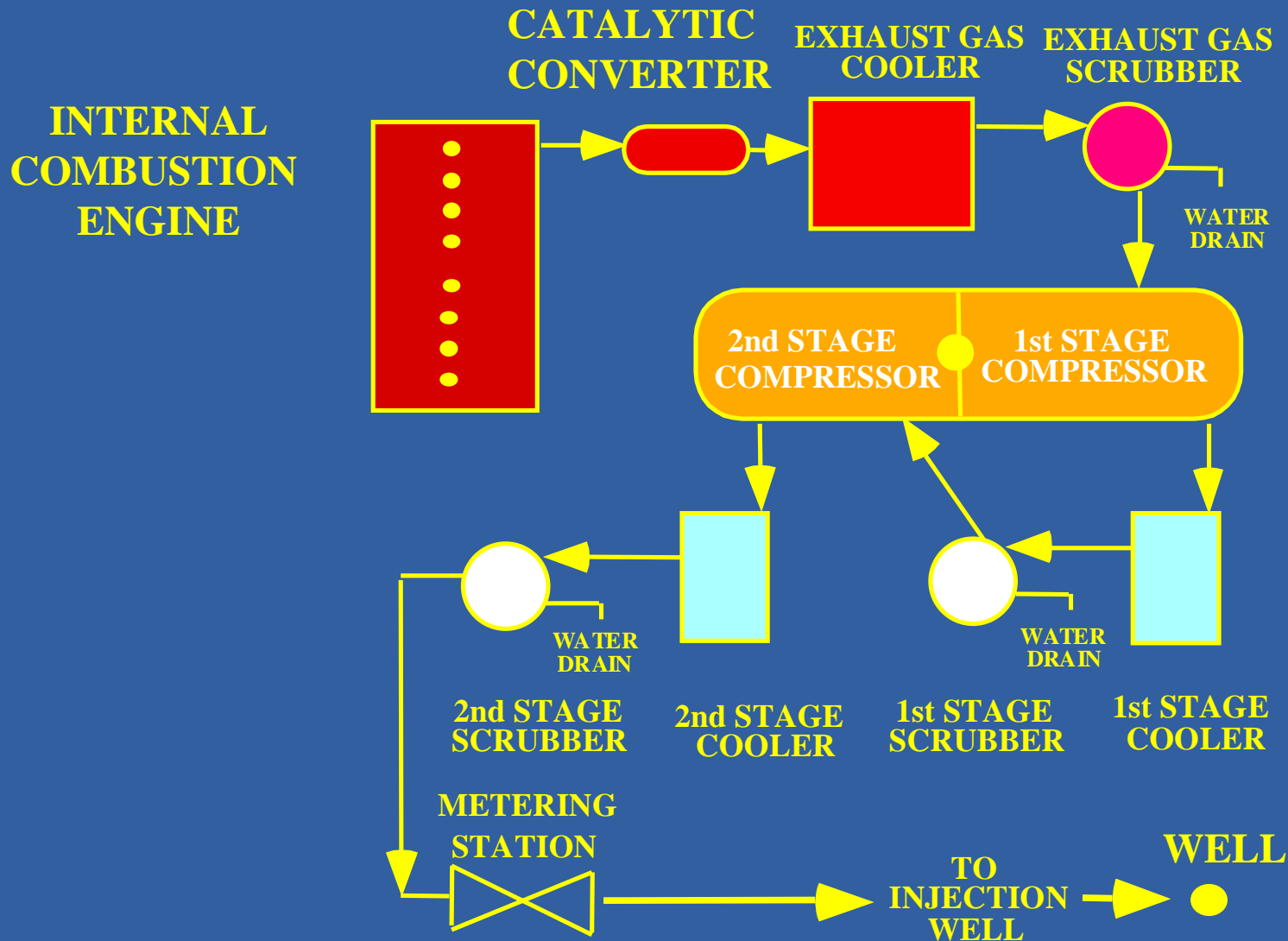
OIL, AVERAGE B / MONTH



GAS, AVERAGE MCF / MONTH

AVERAGE MONTHLY PRODUCTION

DESIGN AND CONSTRUCTION OF SYSTEM






STARTUP PROBLEMS

- ✿ **AQUIRING & DELIVERY OF EQUIPMENT**

- ✿ **ASSEMBLY OF ENTIRE SYSTEM**

- ✿ **WEATHER DELAYS**

OPERATION PROBLEMS

-  **CORROSION OF PIPING IN HIGH TURBULANCE AREAS**
-  **LABOR INTENSIVE, REQUIRES BEING AT PROJECT SITE 24 HRS/DAY (NON-AUTOMATED SYSTEM)**
-  **CHANNELING OF INJECTED GAS**

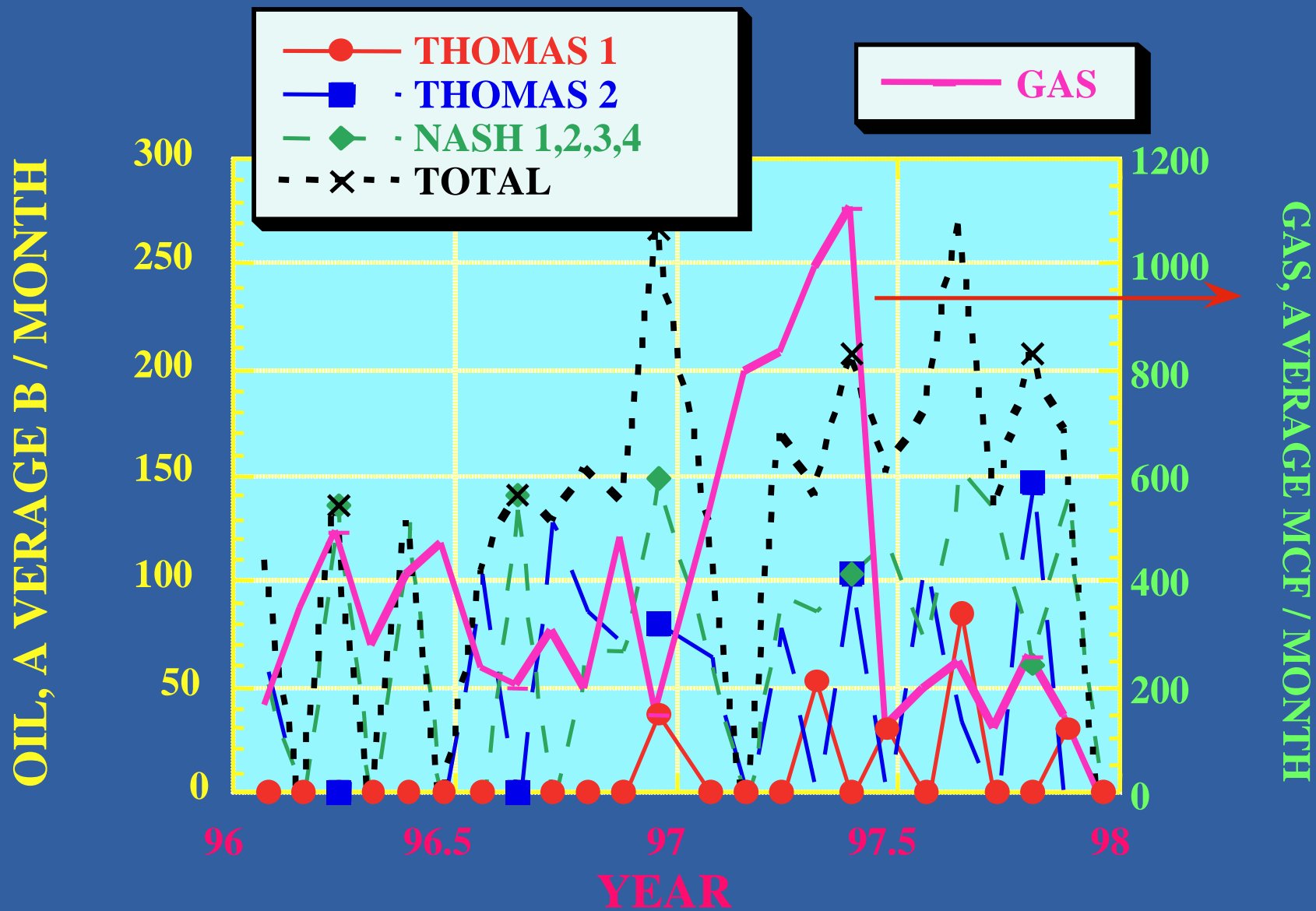
RESPONSE TO GAS INJECTION

- ✿ **TIME FRAME FROM START-UP TO POSITIVE RESULTS WILL NOT OCCUR OVERNIGHT**
- ✿ **ONCE POSITIVE RESULTS START, SLOW DOWN INJECTION VOLUME AND MONITOR INDIVIDUAL WELLS FOR DIRECTION OF GAS**
- ✿ **IN THIS PROJECT, GAS ARRIVED FIRST AT THE PRODUCER WELLBORE AND THEN THE OIL INCREASE ARRIVED**

GAS ANALYSIS BY % FROM NASH LEASE

Component	Pre-project	1/20/97	3/31/97	5/15/97
CO2	0.425	2.971	6.420	6.678
N2	4.531	56.182	72.751	66.090
O2	0.000	0.920	0.000	0.000
C1	62.300	20.987	9.096	13.563
C2	12.654	7.903	3.565	4.371
C3	10.296	6.255	4.638	5.015
IC4	1.241	0.740	0.559	0.659
NC4	3.173	1.881	1.417	1.679
IC5	0.786	0.446	0.335	0.368
NCF	0.929	0.538	0.388	0.377
C6	3.665	1.177	0.831	1.200
	100.000	100.000	100.000	100.000
Z Factor	0.993	0.9978	0.9986	0.9983
BTU - Wet	> 1,400	681.34	399.60	498.19

PRODUCTION BEFORE AND DURING PROJECT



ECONOMICS OF PROJECT







Production Expenses

	Jan-June Prior to Project Monthly	July 1996	July 1997	Oct 1997
Pumper	\$ 500	\$ 2,000	\$ 1,050	\$ 1,100
Electricity	85	130	230	230
Chemical	30	30	80	165
Miscellaneous	25	40	60	15
Ave. Pump Change	140	300	140	150
	<hr/>	<hr/>	<hr/>	<hr/>
	\$ 780	\$ 2,500	\$ 1,560	\$ 1,660

Production Income

Oil Sales	\$ 1,000	\$ 1,000	\$ 1,820	\$ 2,080
Gas Sales	350	350	1,100	1,320
	<hr/>	<hr/>	<hr/>	<hr/>
	\$ 1,350	\$ 1,350	\$ 2,930	\$ 3,400

LESSONS LEARNED FROM PROJECT

-  **ALLOCATION OF TIME**
-  **ANTICIPATE PROBLEMS**
-  **KNOWLEDGE AND USE OF EQUIPMENT**
-  **CONTROL AND MEASUREMENT**
-  **CORROSION CONTROL**
-  **PATIENCE**

PROJECTED ECONOMICS OF PROJECT

Assumed \$80,000 Investment
 \$17.25 / B oil \$1.40 / MCF gas
 Pay Out in 26 Months

YEAR	GROSS MB	GROSS MMCF	NET B	NET MCF	STATE REV	EXPENSE \$	TAX \$	COI \$	INVEST \$	NOI \$	DISC \$
1997	2	6	2022	4835	41647	19200	2915	19532	80000	-60468	-60468
1998	5	11	3890	9304	82109	38400	5748	37961	0	37961	37582
1999	5	11	3685	8814	81675	38400	5717	37558	0	37558	36814
2000	4	10	3481	8324	80993	38400	5670	36923	0	36923	35832
2001	4	10	3276	7835	80038	38400	5603	36036	0	36036	34623
2002	4	9	3071	7345	78786	38400	5515	34871	0	34871	33170
2003	4	8	2866	6855	77208	38400	5405	33403	0	33403	31459
2004	3	8	2662	6366	75275	38400	5269	31606	0	31606	29470
2005	3	7	2457	5876	72956	38400	5107	29449	0	29449	27186
2006	3	7	2252	5386	70217	38400	4915	26902	0	26902	24588
ST	37	87	29663	70940	740904	364800				244241	230242
RM	11	27	9057	21661	328657	224000				81651	72776
TL	48	114	38720	92601	1069561	588800				325892	303018

PROJECTED ECONOMICS OF PROJECT

Assumed \$80,000 Investment
\$17.25 / B oil \$1.40 / MCF gas
Pay Out in 26 Months

YEAR	EXPENSE	DISC
	\$	\$
1997	19200	-60468
1998	38400	37582
1999	38400	36814
2000	38400	35832
2001	38400	34623
2002	38400	33170
2003	38400	31459
2004	38400	29470
2005	38400	27186
2006	38400	24588
ST	364800	230242
RM	224000	72776
TL	588800	303018

CONCLUSIONS

- ✿ **FIRST HAND KNOWLEDGE IN ALL ASPECTS OF THE PROJECT ARE NOT REQUIRED**
- ✿ **BASIC KNOWLEDGE OF OIL & GAS PRODUCTION EQUIPMENT AND USE OF EQUIPMENT IS REQUIRED**
- ✿ **RESOURCES ARE AVAILABLE TO GET HELP — SPEND TIME TO SEEK SOLUTIONS BEFORE INVESTING AND STARTING THE PROJECT —**
- ✿ **DO YOUR HOMEWORK**

WHAT I WOULD DO DIFFERENT NEXT TIME

- 1. SMALLER VOLUME OF INJECTED GAS**
- 2. SEPARATE GAS SUPPLY FROM FUEL SUPPLY**
- 3. INSTITUTE CHEMICAL CORROSION PROGRAM AT START-UP, INSTEAD OF AFTER CORROSION PROBLEMS OCCUR**
- 4. SLOW DOWN INJECTION AND REASSESS AFTER POSITIVE RESULTS OCCUR**
- 5. DO NOT RUSH, IT TAKES TIME TO START REPRESSURIZATION OF FORMATION**
- 6. TEST EACH WELL WITH PORTABLE FLUE GAS GENERATOR BEFORE START-UP OF PERMANENT SYSTEM**

ACKNOWLEDGEMENT

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